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The complex relation between Arctic warming and increased rainfall

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The Arctic region is warming two to three times faster than the global mean, intensifying the hydrological cycle in the high north. Both enhanced regional evaporation and poleward moisture transport contribute to a 50-60% increase in Arctic precipitation over the 21st century. The additional precipitation is diagnosed to fall primarily as rain, but the physical and dynamical constraints governing the transition to a rain-dominated Arctic are unknown. Here we use 37 global climate models in standardised 21st-century simulations to demonstrate that, on average, the main contributor to additional Arctic (70-90°N) rainfall is local warming (∼70%), whereas non-local (thermo)dynamical processes associated with precipitation changes contribute only 30%. Surprisingly, the effect of local warming peaks in the frigid high Arctic, where modest summer temperature changes exert a much larger effect on rainfall changes than strong wintertime warming. This counterintuitive seasonality exhibits steep geographical gradients, however, governed by non-linear changes in the temperature-dependent snowfall fraction, thereby obscuring regional-scale attribution of enhanced Arctic rainfall to climate warming. Aggregate Arctic snowfall is projected to decline after 2040, despite accelerating total precipitation. Detailed knowledge of the underlying causes behind Arctic snow/rainfall changes will contribute to more accurate assessments of the (possibly irreversible) impacts on hydrology/run-off, permafrost thawing, ecosystems, sea ice retreat, and glacier melt.